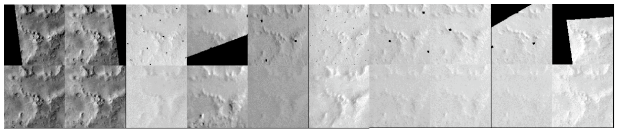
Exploring the Synthesis and Visualization of Martian Terrain Models

Dave Curkendall, James Collier, Bob Gaskell, Jonathan Howell, Craig Miller, Herb Siegel
NASA's Jet Propulsion Laboratory, California Institute of Technology

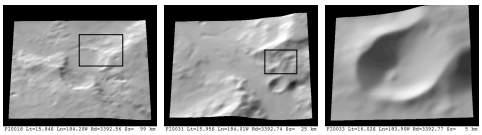
OVERVIEW: Significant progress has recently been made in the development of coherent techniques to derive high resolution 3D topographic and albedo models of Martian terrain from satellite imaging and MOLA data. In some cases, a 30m resolution model may be derived from the best 1km MOLA MEGDR data. The resulting site model has the potential to assist the planning of landed operations such as a rover traverse and the interpretation of resulting rover and lander imagery. Our objective was to explore the feasibility of merging these 'wide area' site models with the emerging in situ model and to develop formal tools to exploit the wide area model as well as the two models working together.

Site Model Created with Stereo Photoclinometry



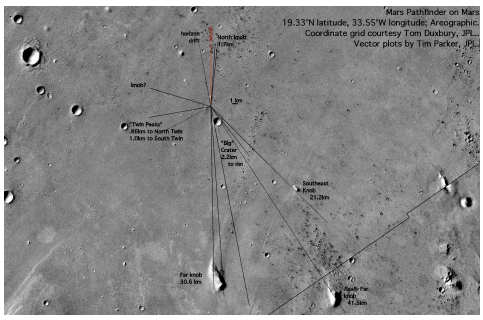
Above, stereo photoclinometry techniques have been applied to the satellite images in the top row of a candidate landing site in Isidis in order to estimate the local slope from differences in shading due to differences in sun azimuth and elevation. The bottom row are images of the resulting Digital Elevation Model (DEM) lit with a sun position corresponding to the satellite image immediately above it.

Site Model Created with Stereo Photoclinometry and MOLA

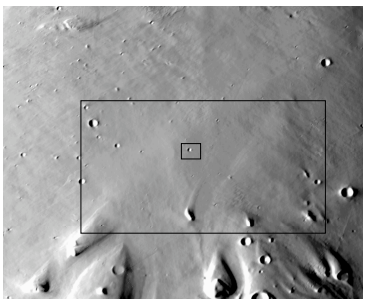


The 1km MOLA data can be used as benchmarks that both constrain the stereo photoclinometry estimation process and tie the resulting model to the global MOLA grid. A portion of the Martian surface near Gusev crater is shown above. On the left is a 1000m model using MOLA data only. Zooming in using high resolution Viking images are a 250m model (center) and a 50m model (right).

Pathfinder Landing Site

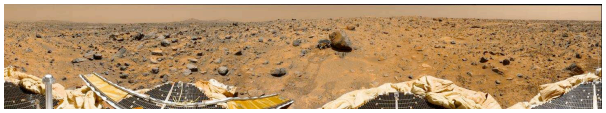


Above is a 2D image originally used to locate the Pathfinder landing site in relationship to nearby landmarks. This image corresponds to the larger rectangle in the WATM to the right.



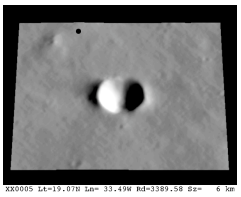
Pathfinder Wide Area Model (WATM)

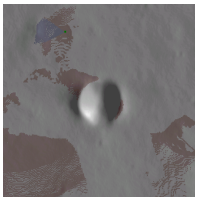
One goal for this task was to extend these estimation techniques to much wider areas while retaining a resolution as high as the underlying imaging data – in the case of the Pathfinder site about 30m – using both MOC and Viking images. The 125m resolution Wide Area Terrain model (WATM) to the left was created using 1km resolution MOLA data and 22 overlapping images. The Pathfinder landing site is at the center of this 128km square model. Further effort will be needed to complete at 30m.



The Martian panorama above from the Pathfinder lander raises a number of interesting questions:

- Can the wide area terrain model (WATM) help identify objects in the far field of landed imagery?
- Can this identification result in an accurate determination of the actual landing site?
- When the landing site is known, can we use the WATM to interpret the far field content of a landed imagery?
- Can synthetic enhancement (i.e., adding fine details to the site model of a given site be helpful?
- Can the WATM be the basis for planning and assessing the difficulties of long rover traverses; in particular, can it be used to assess visibilities versus rover position?





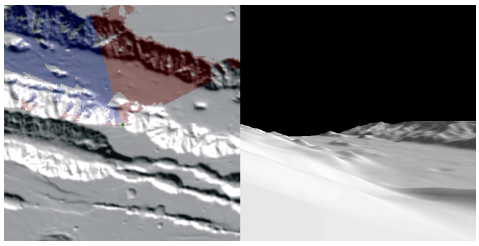
6km Pathfinder WATM Submodel

The images above were generated from a 6km square subset in the center of the WATM and correspond to the small box in that image. The Pathfinder landing site is the black dot in the left image and is just to the right of the 'twin peaks' landmark. A tool was developed to estimate viewpoint location based on observed landmarks. However, the individual peaks of 'twin peaks' are not yet resolved at 125m resolution indicating that the 30m resolution model is needed. The image on the right indicates that both the 'twin peaks' and the rim of the crater should be visible from the lander. This image was generated from the WATM using a new tool, glDEM, for studying regions of visibility. This tool provides a perspective view from any location on or above the model together with a corresponding orthographic view from above highlighted green at the current view point, blue on the region visible in the perspective view, and red in the remaining visible regions.

In order to study a 3D visualization of a composite WATM and an in situ model a complete Open Inventor based **Terrain Viewer** was constructed. Features include:

- Rendering of large data sets through out of core paging techniques
- View Dependent refinement through frustum and threshold culling
- Geomorphing to prevent popping when introducing a new refinement level
- Fast triangle strip construction
- Portable libraries
- Consistent with a design for collaborative viewing over wide area networks.

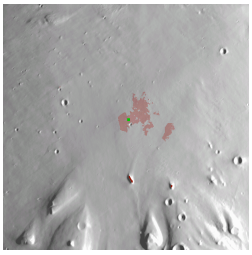
Below are images that show the output of the visibility tool for a 1km resolution DEM of Valles Marineris interpolated from the MOLA MEGDR data set:



Visibility Regions in Valles Marineris

Pathfinder In Situ Model Embedded in Synthetic WATM

The images above were rendered using the Terrain Viewer. The left view is a 4km square synthetic terrain generated at 1m resolution. The middle view zooms into a crater near the top left and starts to make visible the embedded in situ model. The right view comes into that model and creates a perspective view containing elements of both the in-situ and the WATM models



Possible Landmarks

This visibility experiment indicates that the 'Far knob' and the 'Really Far knob' should be visible in the WATM of image 3 from about 10m above the Pathfinder landing site. Hence, climbing a nearby hill might provide these landmarks for help in position location and surface navigation. Landmarks further south are not visible due to the planetary curvature.